TOPIC: Ecosystems- components, types, energy flow; Food chain, food web.

The living organisms and non-living environment are inseparably inter-related and also interact with each other. Keeping this view in mind, the term ecosystem was proposed by the British ecologists **A. G. Tansley** (1935), who defined the ecosystem as "The system resulting from the integration of all the living (Biotic) and non-living (Abiotic) factors of the environment." Same idea was proposed by **V. Sukachaev** (1944) in the term of **Biogeocoenosis.**

Components of ecosystem

The biotic and abiotic parts are the basic components of ecosystem—

(1) Abiotic components: Basic abiotic components are:

(i) **Inorganic substances** like C, N, P, H, O, S, etc. which are involved in the mineral cycle.

(ii) Organic compounds: It includes carbohydrates, fats, proteins, which link the biotic and abiotic components eratuke.

(iii) Climatic regime: Solar radiation, temperature, and other physical factors making the climate to the given region.

(2) Biotic components: These are represent trophic (nutrition) structure of any ecosystem where living organisms are distinguish on the basis of their nutritional relationships—

(a) Autotrops or Producers: Green plants including photosynthetic bacteria, which they build organic food through the process of photosynthesis.

It also includes some chemosynthetic bacteria which also contribute to build of organic matter.

(b) Heterotrops or Consumers: These are fungi, most of the bacteria and animals. These lack chlorophyll and obtain their food energy directly or indirectly from the autotrops. It further categorised into—

(i) Macro-Consumers —These denotes orderly placed animals-such as, herbivores (Primary consumers), Carnivores (Secondary Consumer) based on the pattern of food chain.

(ii) Micro-Consumers (Decomposers) —It includes mainly bacteria, Achnomycetes and fungi. They break down of complex compound or living protoplasm into simpler substances and release them. So that these substances can be reutilised by the primary producers.

Trophic Structure

The producers-Consumers arrangement is one kind of structure called as trophic structure.

(i) Food Chain: Simple and linear relationship between the producer and consumer of different trophic level is called food chain. In this case the food energy moves from green plant to the top carnivores in one linear direction e.g., grass gives food to grasshopper which are eaten by frog and frogs are eaten by snake.

Grass → Grasshopper → Frog → Snake

It is of 3 types —

(A) Predator Chain —Start from producers through herbivores and end to the carnivores e.g. –

Green plants → Rabbit → Jackal → Tiger

(B) Parasitic Chain —Starting from larger animals and goes to smaller animals, e.g.

Human beings → Helminthes → Bacteria → Crop plant → Parasite → Hyper parasite.

(C) Saprophytic Chain —Start from organic materials and goes to micro-organisms, e.g.,

Fallen twig or leaves → Primary colonizer → Secondary colonizer.

(ii) Food Web—In any ecosystem no organism is fully dependent on only one source.

The linear arrangement of food chains interconnected with each other through different types of organisms at the different trophic levels. In this case feeding relationship are not in chain but net like. This net like relationship between producers and consumers of different level is called Food Web.

(iii) Trophic level—The food chain in any ecosystem can not be more than five stage (Elton 1947). All the organism with similar feeding habitats in food chain have been grouped together as trophic level. The graphic representation of trophic level is given below—

Producer → Herbivores → Carnivores → Top Carnivores → Decomposers

T_1 T_2 T_3 T_4 T_5

The no. of organism at T_1 is always higher than that of T_2, T_3, T_4, level at least.

Characteristics of Grazing Food Chain

(a) These are directly dependent upon solar radiations as the primary source of energy and the producers (green plants) synthesize their plant biomass by the process of photosynthesis. Producers form the first trophic level.

(b) Herbivores or primary consumers eat upon the producers and form the second trophic level.

(c) Herbivores are in-turn eaten by different categories of carnivores forming the higher trophic levels.

(d) Grazing food chains are longer food chains and they always end at decomposer level.

Type of Ecosystem	Producers	Herbivores	Primary Carnivores	Secondary Carnivores	Tertiary Carnivores
A. Grassland Ecosystem	1. Grasses 2. Grasses 3. Grasses	Insects Rats and Mice Rabbit	Frogs Snakes Fox	Snakes Predatory Birds Wolf	Predatory Birds Lion
B. Pond Ecosystem	Phytoplankton	Zooplanktons	Small Fishes	Large Fishes	Predatory Birds
C. Forest Ecosystem	Trees	Phytophagous Insects, Herbivore Mammals	Lizards Birds Foxes	Lions Tigers Etc.	

Characteristics of Detritus Food Chain

a) Primary source of energy is dead organic matter called 'detritus' which are fallen leaves, plant parts or dead animal bodies.

b) Primary consumers are 'detritivores' including protozoans, bacteria, fungi, etc which feed upon the detritus saprophytically.

c) Detritivores are in turn eaten by secondary consumers such as insect larvae, nematodes, etc.

d) Detritus food chains are generally shorter than grazing food chains

e) In nature, detritus food chains are indispensable as the dead organic matter of grazing food chain is acted upon by the detritivores to recycle the inorganic elements into the ecosystem.

Detritus food chain

Detritus	Detritivores	Detritivores Consumers	Small Carnivores	Large Carnivores
Mangrove Follen Leaves and Dead Bodies	Fungi,Bacteria and Protozoans	Insect Larvae,Certain Crustaceans,Molluscs and Fishes	Minnows Small game fish etc.	Large Fish,Fish eating Birds

Differences between Grazing and Detritus food Chains

Characters	Grazing food chain	Detritus food chain
Primary source of energy	Solar radiations	Detritus
First trophic level	All herbivores	Detritivores (a mixed group in terms of trophic levels and may be herbivores, omnivores and primary carnivores)
Size	Long-sized chains	Small-sized chains

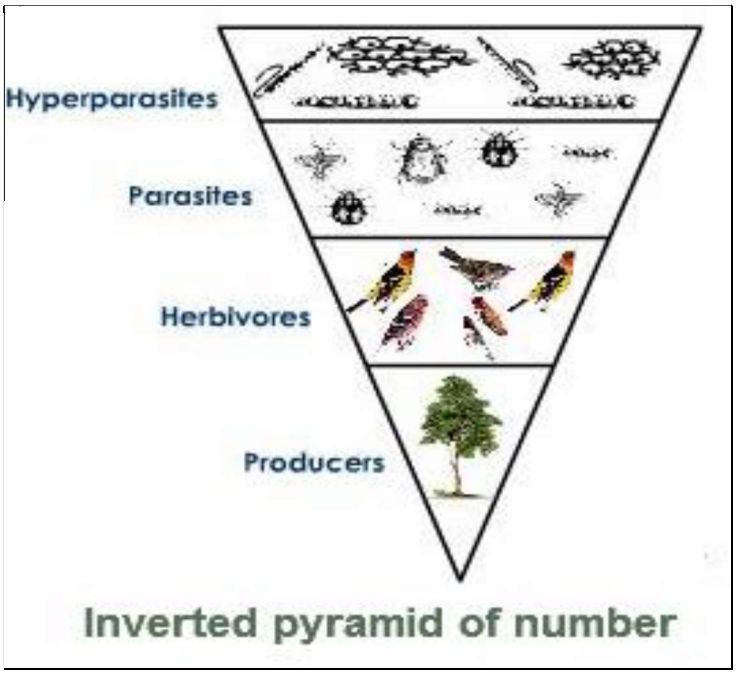
1. **Ecological Pyramid**— **Ecological pyramids** are diagrams that illustrate how ecologically important factors, such as energy, biomass, and population size, vary between trophic levels in an ecosystem.

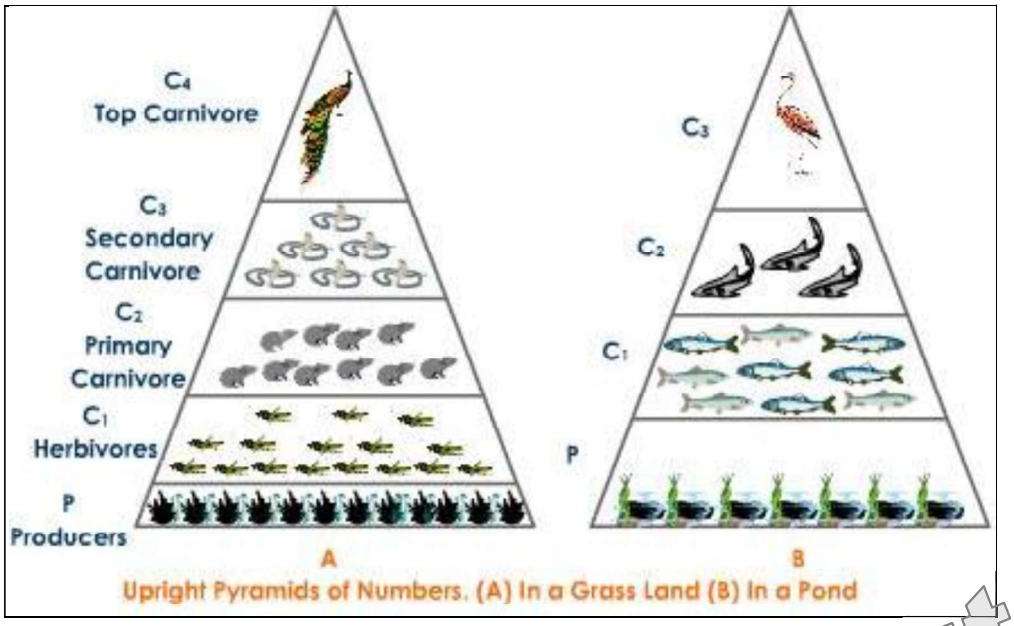
The trophic structure and function at successive trophic level form the ecological pyramids i.e. → producers → herbivores → carnivores, may be shown by means of ecological pyramids.

(a) Pyramid of number— It deals relationship between the number of primary producers and consumers at different trophic levels.

(i) In crop land ecosystem primary producers are large in numbers forming upright pyramid.

(ii) In forest ecosystem when the primary producers are less number forming pyramid which is inverted.



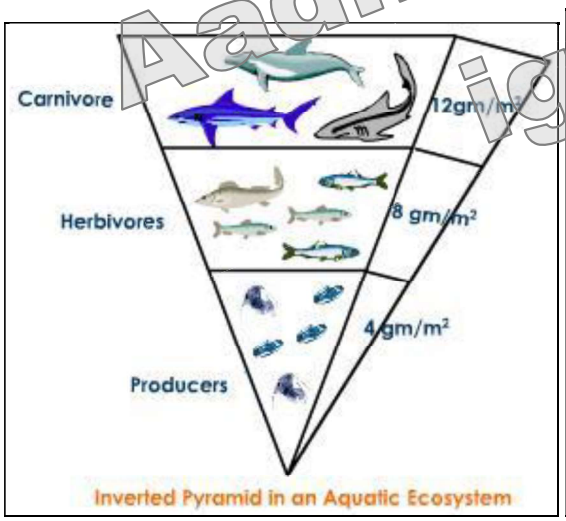


Upright Pyramids of Numbers. (A) In a Grass Land (B) In a Pond

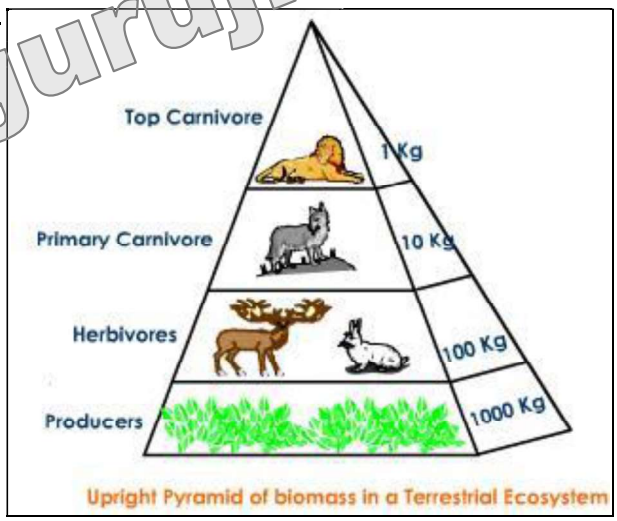
(b) Pyramid of biomass:

(i) In terrestrial ecosystem, the biomass of all the primary producers is always maximum and top carnivores have low biomass. So it is upright pyramid.

(ii) In aquatic ecosystem the biomass of consumers is always higher than primary producers & invert pyramid.



Inverted Pyramid in an Aquatic Ecosystem



Upright Pyramid of biomass in a Terrestrial Ecosystem

(c) Pyramid of energy: It represent the productivity of the system at each trophic level values of energy accumulation at each level per square metre per yr. are obtained for any ecosystems.

Such pyramid for all ecosystems is always upright. T_1 possess maximum value, starting from herbivores the energy value per square metre year increase by l/10th.

TOPIC: Colorimetry

- **Colorimetry is the field of determining the concentration of a coloured compound in a solution. A colorimeter, also known as a filter photometer, is an analytical machine that acts as the tool quantify a solutions concentration by measuring the absorbance of a specific wavelength of light.**
- Colorimeters are used for a wide range of applications across the chemical and biological fields including, but not limited to, the analysis of blood, water, nutrients in soil and foodstuffs, determining the concentration of a solution, determining the rates of reaction, determining the growth of bacterial cultures and laboratory quality control.

Colorimeter Principles

- Colorimeters are used to detect colour and determine the solutions concentration, i.e. when a wavelength is passed through a sample, some of the light is absorbed and some passes through. It is the wavelengths of light that pass through that are detected
- By knowing which wavelengths have passed through the detector can also work out which colored wavelengths were absorbed.
- If the solution to be tested is colourless, a common procedure is to introduce a reagent that reacts with the solution to produce a coloured solution. The results are compared against known standards.
- The colorimeter uses the Beer-Lambert law to detect the absorbance of the wavelength. Beer-Lamberts law is commonly written as:

$$A = \varepsilon cl$$

- Where, A is the absorbance, ε (epsilon) is the molar absorptivity, c is the concentration of the solution and l is the length that the light passes through (also known as the mean free path).
- Aside from this, if there is a continual changing of the solution, i.e. it is a reaction, then % of transmittance against time is generally used.

What is Colorimeter?

- A Colorimeter is a light and sensitive device used to measure the transmittance and absorbance of light that passes through a liquid sample.
- The colorimeter device also measures the intensity or color concentration that develops upon introducing a particular reagent into a solution.

These are Divided into Two Types.

- **Color densitometers,** which measures the density of primary colors,
- **Color photometers,** which measures transmission and color reflection.
- Usually, the Colorimeter is used to measure the known solute concentration in a given solution with the help of Beer-Lambert law. **The Colorimeter was invented by Louis J Duboscq, in the year 1870.**

Principle of Colorimeter

Let us discuss the principle of colorimeter. A photometric is a technique which states that when a beam of incident light of intensity I_o passed through a solution, it occurs the following.

A part is reflected which is denoted as I_r

A part is absorbed which is denoted as I_a

The remaining light is transmitted, which is denoted as I_t

Thus, $I_o = I_a + I_r + I_t$

- To determine Ia, the measurement of It and Io is sufficient. Therefore, I_r is eliminated and the amount of light reflected is kept as constant to measure It and Io.
- The Colorimeter is based on two fundamental photometry laws. Let us discuss them briefly.

Beer's law

This law states that the amount of light absorbed is always proportional to the solute concentration present in the solution.

$$\text{Log10 } I_o/I_t = a_s c$$

Where c is the concentration of the solution, and as is absorbency index.

Lambert's law

$$A = \log 10\ I_o/I_t = a_s b$$

Where, as is the standard absorbance and A is the test absorbance of the test, and b is the thickness/length of the solution.

Working of Colorimeter

As discussed in the Colorimeter's different principles, let us look at the working of colorimeter.

Step 1

Before going to start the experiment, it is essential to calibrate the Colorimeter. It can be done with the help of the standard solutions of the known solute concentration that has to be determined. Then, fill the standard solutions in the cuvettes and place it in the cuvette holder of the Colorimeter.

Step 2

A light ray of a particular wavelength specific for the sample is in the direction of the solution. The light travels through a series of various filters and lenses. The colored light, then navigates by taking the help of lenses, and the filter allows the split of a beam of light into different wavelengths allowing only the required wavelength to pass through and reach the standard test cuvette.

Step 3

As the light beam reaches the cuvette, it is transmitted, reflected, and absorbed by the solution. The transmitted ray falls on the photodetector system, where the intensity of transmitted light is measured. Now, the photodetector system converts the beam into the electrical signals and sends it to the galvanometer.

Step 4

The electrical signals that are measured by the galvanometer displays in the digital form.

Step 5

Formula to determine the substance concentration in the test solution is,

$$A = \in cl$$

Where $\in$ and l are constant for the standard and test solutions,

$$A_T = C_T \text{ ---- (i)}$$

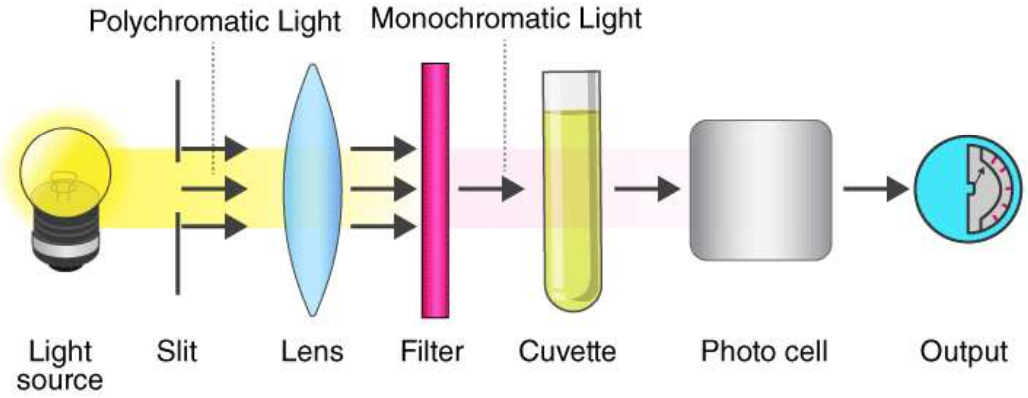
$$A_S = C_S \text{ ---- (ii)}$$

From the above two equations, we get the colorimeter formula as,

$$A_T \times C_S = A_S \times C_T$$

$$C_T = (A_T/A_S) \times C_S$$

Where A_T is the optical density/absorbance of the test solution, A_S is the absorbance / optical density of the standard solution, C_T is the concentration of the test solution, and C_S is the standard concentration.



- To measure concentrations, the amount of light absorbed is dependent upon the amount of solute (also known as the analyte as it is the species being measured) in the solution- a higher concentration of dissolved solute means that more light will be absorbed, and vice versa, hence, the concentration can be backed out from the absorption of specific wavelengths.

The Colorimeter Itself

- A colorimeter is composed of many parts. Aside from using a known standard solution, alongside either known concentrations and unknown concentrations, there are many vital components to a colorimeter.
- As the principles are based around light, a light source is required and usually takes the form of a filament lamp.
- Other components include an adjustable aperture to let the light through, coloured filters to filter specific wavelengths of light, a cuvette to hold the solution (commonly made of quartz), a photodetector to measure the transmitted light and a meter to quantify the values into a readable output.
- The coloured filters are chosen to select the wavelength in which the dissolved solute will absorb the most.
- For most experiments the common wavelength range is between 400 and 700 nm, but when some analytes absorb in the ultraviolet range (less than 400 nm) then modification of the colorimeter is generally required.
- This normally takes the form of removing the filament lamp and replacing it with light-emitting diode(s) of a specific colour.
- The output can be either analogue or digital in nature and, depending of the principle used, will give either an absorbance (0-infinity logarithmic output) or a %transmittance (0-100%) readout. The ideal output for an absorbance measurement is between 0 and 2, but it is desirable to have a reading between 0 and 1, as above 1 the results can become unreliable due to the scattering of light. The readout is usually in the form of a spectrum.
- Most calorimeters will require calibration, which is the solvent alone and not the measurable contents with the solvent- i.e. a standard or 'blank' solution.
- The calibration allows the absorbance of the solvent to be measured, also known across many instruments as the background noise.

- Once measured, the solvent absorption values are removed from any future readings, allowing the absorbance (or %transmittance) to be calculated (and plotted on a spectrum) for the desired analyte(s) without noise interference.
- There are a wide variety of colorimeters out there, where some colorimeters are large machines and generally used for a wide-range of laboratory analyses, but some colorimeters are now hand-held and can be used for on-site analyses such as the determination of *in-situ* water and soil samples. In the case of handheld colorimeters, a numerical readout is the common procedure as opposed to a spectrum found on the larger laboratory machines.

Colorimeter Uses

- Colorimeter device is used to test the water quality by screening chemicals such as chlorine, cyanide, fluoride, dissolved oxygen, iron, zinc, hydrazine, and molybdenum.
- Colorimeters are widely used to monitor bacterial growth or yeast culture.
- They provide highly accurate and reliable results when used for the assessment of color in bird plumage.
- They are also used to monitor and measure the colour in various foods and beverages, including sugar and vegetable products.
- It is used in hospitals and medical laboratories to estimate biochemical samples, including plasma, urine, cerebrospinal fluid, serum, and a few more.
- Besides, it helps in the identification of counterfeit and substandard drugs.
- Most of the food industries use this device.
- Paints and textile manufacturers use a colorimeter.
- This device often checks the strength and durability of the colours in paints and fabrics to ensure a similar quality

Secondary Level

UNIT-1 Taxonomy

CONTENT

Unit-2

Structural organization in Animals and Plants

CONTENT

unit 3

Cell Structure and Functions

CONTENT

UNIT-4

Animal Physiology

CONTENT

Unit-5

Reproduction in Plants

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Unit-6

Genetics and Evolution

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Unit-7

Biology and Human Welfare

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Unit-8

Ecology and Environment

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Graduation LEVEL

Unit-1

Taxonomy

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Economic botany -Zoology

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Embryology

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Unit-7

Plant Physiology

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Unit-8

Biostatistics

CONTENTS

CONTENT- PG LEVEL

Description of Obelia:

Obelia belongs to the animal kingdom within the hydrozoa class and has many sp... outlines how the obelia is classified in biology:

- **Kingdom** - Animalia (animals)
- **Phylum** - Cnidaria (sea anemones, corals, jellyfishes, and other relatives)
- **Class** - Hydrozoa (characterized by bodies that are radially symmetrical)
- **Order** - Leptothecata (Hydrozoans whose hydranths are covered with gonophor...
- **Family** - Campanulariidae (stinging celled animals composed totally of hydroids)
- Genus Obelia

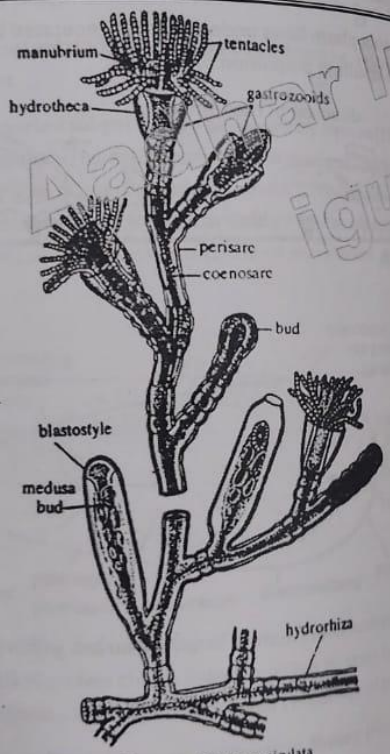


Fig. Obelia geniculata

- **Common Species** - Obelia bidentata (double toothed hydroid), Obelia castel... (sea thread hydroid), Obelia fimbriata, Obelia geniculata (knotted thread hy... Obelia logic yatha, Obelia longissima (Sessile hydroid).
- **Geographical distribution** - widely distributed from the arctic region down t... the Pacific coast. Also, from southern California to Oregon.
- **Sense organ** - Statocyst

...is a branched, fixed colony. **Some of the horizontal branches anchoring the colo... Hydrorhiza while other branches are vertical and known as Hydrocaulus.**

...ch branch consists of a granular coenosarc made of two cell layers enclosi... ...rounded by a thin transparent horny perisarc.

...e vertical branches towards the base are further branched and all the branches e...

...oids are of three types:

a. Polyps or gastro zooids (vegetative zooids). Barrel-shaped and responsible... colony. **The perisarc enclosing the polyp is termed hydro theca.**

b. Blastostyles, or gonozooids. Club- shaped zooids, bearing the medusae bud...

c. Medusae buds. Umbrella-like reproductive zooids bearing gonads, enclosed...

...usae buds are unisexual and free- living at maturity. One medusa bears either fou... ...o the four radial canals.

...tentacles in all cases are solid; the solid core or endoderm surrounded by a laye...

...larvae are ciliated and free-swimming.

...peated branching of the simple polyps colony is formed.

Polyps or Gastro zooids or Nutritive Zooids:

...ooid is barrel-shaped, partially enclosed ...-shaped hydro theca, a continuation of ...sarc.

...e distal end a conical projection the ...ne or- manubrium, bearing a mouth is ...

...let of about twenty-four tentacles are ...round the hypos tame. The tentacles ...with a core of endoderm cells ...ed by a layer of ectodermal cells.

...entacles and the hypostome bear ...s.

...proximal end, the zooid is continuous ...oenosare.

2. ***Holcocera pulverea.*** The damage by the brownish larva is similar to the above species. Pupa is slightly bigger and yellowish-brown.

Parasites:

- The following insects are parasitic on lac insect.
- ***Paraecthrodryinus clavicornis; Erencyrtus dewitzi; Tachardiaephagus tachardiae; Eupelmus tachardiae; Tetrasticus purpurens.***
- The above natural enemies can be controlled by maintaining healthy cultures and by enclosing the brood lac sticks in wire mesh before inoculation so that natural enemies are not able to emerge and cause re-infestation.

The Honey Bee: apiculture

- Honey bees are colonial insects that visit flowers, collect nectar and convert it into a golden-yellow aromatic viscous fluid called honey, which is also called the liquid gold of nature.
- There is nothing comparable to honey, whether natural or manmade.
- It is a complete food made and stored by honeybees for the whole colony.
- Honey contains about 80% sugars, mainly glucose and fructose.
- Harmful sucrose is only 1-2% in honey.
- In addition, honey contains all essential vitamins, minerals and proteins.
- It has antiseptic properties, is a good blood-purifier, removes gastric problems and corrects metabolic imbalances in the body.
- It gives instant energy to sportspersons.
- A bee colony has about 20,000 workers, one queen and about two dozen drones.
- Queen can lay up to 3000 eggs per day, which is twice the weight of her body but normal fecundity is about 600 eggs per day.
- Queen can produce male or female offsprings by choice; unfertilized eggs develop into males and fertilized ones into females.
- Growing larvae can also be developed into queens or workers by choice, both of which are genetically females. Males are called drones, which are darker, robust and hairy and larger than workers.
- There are about two dozen of them in a hive and chase the queen in air every time she ventures on nuptial flight.
- One of them manages to mate with her during
- such flight and dies in the process. Drones are not tolerated in the hive once the queen is fertilized and are generally driven out of hive, where they eventually die of starvation.

A worker has a lifespan of 6 weeks, the first half of which is spent in the hive attending to household chores, secreting wax and building hive, producing a highly nutritious royal-jelly and converting nectar into honey.

	Cephalopoda	Squids and octopuses
Phylum	Arthropoda (jointed limbs, hard exoskeleton)	
	Crustacea	Water fleas, Sacculina, Barnacles, Shrimps, Woodlice, Prawns, Crayfish, Lobsters, Crabs
	Myriapoda	Centipedes and millipedes
	Arachnida	Eurypterids (fossils), horseshoe crab (Limulus), scorpions, mites, ticks, spiders.
	Insecta	Cockroach, lucust, aphids, lice, mosquitoes, flies, fleas, bees, bug (e.g. rhodnius), butterfish and moths
Phylum	Echinodermata (Spiny-skinned, pentaradiate)	starfish, brittle stars, sea urchins, sea cucumbers, sea lilies.
Phylum	Chordata (possess notochord at some stage in life history)	
	Protochordata (invertebrate chordates)	sea squirts, acorn worms, amphioxus
	Vertebrata (notochord replaced by vertebral column)	
	Cyclostomata (jawless fishes)	Lampreys and hagfishes
	Pisces (true fishes)	Elasmobranchs (Modern cartilaginous fish) e.g. dogfish, rays, sharks, teleosts (modern bony fishes) e.g. cod.
	Amphibia	Newts, salamanders, frogs, toads
	Reptilia	Dinosaurs, lizards, crocodiles, turtle snakes
	Aves (birds)	Pigeons, gulls, kiwi, ostrich etc.
	Mammalia	
	Monotremes (egg-lying)	duck-billed platypus, spiny anteater
	Marsupials (pouch mammals with rudimentary non-allantoic placenta)	opossums, tasmanian wolf (thylacinus), koala bear, kangaroos
	Eutherians (have true placenta)	the many group include the rodents great cats, and primates (e.g. baboons, chimpanzee, man)

Taxonomical Aids

s very useful for us to make a study on diverse organisms and learn about them. We can exploit this wledge of various species of plants, animals and other organisms. It is thus necessary to make accurate dies about them. This accurate classification demands rigorous hard work. The first step is the collecting of

er 3. Neogastropoda (Stenoglossa)

Shell with a short to a very long siphonal canal.
Radula consists of rows with 2 or 3 teeth in each row.
Nervous system concentrated.
Osphradium is large.
Free-swimming veliger suppressed.
Examples: *Murex*, *Nassarius*, *Oliva*, *Magilus*, *Buccinum*.

lass 2. Opisthobranchia

Exclusively marine gastropods.
Shell small without operculum or no shell.
Shell when present covered with mantle or pedal cord.
Body mass torted or detorted.
Gills posterior to the heart.
Heart with one auricle posterior to the ventricle.
One kidney, one gonad.
The nervous system concentrated due to detorsion.
Monoecious; larva veliger.

er 1. Cephalaspidea

Shell present but may be partly or wholly enclosed by the mantle.
Head with the tentacular shield.
Lateral parapodial lobes prominent.
Examples: *Acteon*, *Hydatina*, *Bulla*.

er 2. Anaspidea

Found mostly in tropical or subtropical waters.
Shell usually reduced or less covered by mantles.
Well-developed parapodial lobes.
Anterior end bears a pair of tentacles, a pair of rhinophores and a pair of eyes.
Sperm ducts open, running the body length to the penis located anteriorly.
Examples: *Aplysia*, *Akera*.

er 3. Pteropoda

Pelagic snails with or without a shell.
Parapodial fins for swimming.
With or without a mantle cavity.
Head with a pair of rhinophores.
Protandrous, hermaphrodites with an open sperm groove.
Examples: *Spiratella*, *Cavolina*, *Clione*, *Peraclis*.

er 4. Sacoglossa

With or without the shell.
The pharynx is suctorial.

* Arsenic
* Cadmium

Bioremediation.

- By definition, **bioremediation is the use of living organisms, primarily microorganisms, to degrade the environmental contaminants into less toxic forms. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment.**
- The microorganisms may be indigenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site.
- Contaminant compounds are transformed by living organisms through reactions that take place as a part of their metabolic processes.
- Biodegradation of a compound is often a result of the actions of multiple organisms. **When microorganisms are imported to a contaminated site to enhance degradation we have a process known as bioaugmentation.**
- **For bioremediation to be effective,** microorganisms must enzymatically attack the pollutants and convert them to harmless products.
- As bioremediation can be effective only where environmental conditions permit microbial growth and activity, its application often involves the manipulation of environmental parameters to allow microbial growth and degradation to proceed at a faster rate.
  - **Like other technologies, bioremediation has its limitations.**

Some contaminants, such as **chlorinated organic or high aromatic hydrocarbons, are resistant to microbial attack.** They are degraded either slowly or not at all, hence it is not easy to predict the rates of clean up for a bioremediation exercise; there are no rules to predict if a contaminant can be degraded.

FACTORS OF BIOREMEDIATION

The control and optimization of bioremediation processes is a complex system of many factors. These factors include: the existence of a microbial population capable of degrading the pollutants;

- the availability of contaminants to the microbial population;
- the environment factors (type of soil, temperature, pH, the presence of oxygen or other electron acceptors, and nutrients).

1. MICROBIAL POPULATIONS FOR BIOREMEDIATION PROCESSES

Microorganisms can be isolated from almost any environmental conditions. Because of the adaptability of microbes and other biological systems, these can be used to degrade or remediate environmental hazards. **We can subdivide these microorganisms into the following groups:**

***Aerobic*: In the presence of oxygen. Examples of aerobic bacteria recognized for their degradative abilities are *Pseudomonas*, *Alcaligenes*, *Sphingomonas*, *Rhodococcus*, and *Mycobacterium*.** These microbes have often been reported to degrade pesticides and hydrocarbons, both alkanes and polyaromatic compounds. Many of these bacteria use the contaminant as the sole source of carbon and energy.

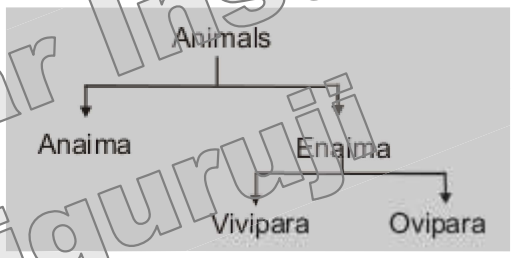
Topic: Taxonomy Basics

- Taxonomy is the branch which deals with the study of nomenclature, classification and their principles.
- Taxonomy word was given by "A.P. de Candole. It is a Greek word.
- Taxis – arrangements. Nomos – Law.

Father of modern Taxonomy - Carolus Linnaeus

1. Aristotle

- He is called as the Father of Zoology. He is also known as the Father of ancient animal – Classification
- He classified first of all the known animals of his times into two groups on the basis of their natural similarities and differences & blood colour in his book **Historia animalium**.
- These groups were Anamia & Enaima.
    - **Anaima -** Animals without red blood cell. e.g. Sponges, Cnidaria, Mollusca, Arthropoda, chinodermata.
    - **Enaima -** These animals have red blood. This group includes all vertebrates and it has been further divided into two subgroups :-
- **Vivipara :** Which give birth to young-ones. e.g. Man, Whale and other mammals.
- **Ovipara :** Which lay eggs. e.g. Amphibians, Pisces, Aves, Reptiles etc.



2. Pliny

- He classified animal into two groups:-
    - **Flying -** Animals which can fly.
    - **Non-Flying -** Animals which cannot fly.

John - Ray : He defined the term "species". He first used the term "species". The smallest unit of classification is the species.

- **Mayer (**Darwin of 20th century**): -** Gave the modern definition of animal-species. According to him, the group of animals which are capable of interbreeding in natural conditions are of the same species.

3. Carolus Linnaeus

- The Binomial system of Nomenclature was extensively used by Linnaeus.
- It was developed by Gasperd Bauhin (1735).
    - Species Plantarum is a book by Carl Linnaeus, originally published in 1753, which lists every species of plant known at the time, classified into genera. It is the first work to consistently apply binomial names and was the starting point for the naming of plants.
    - Genera Plantarum is a publication of Carl Linnaeus. The first edition was issued in Leiden, **1737**. **The fifth edition served as a complementary volume to Species Plantarum (1753).**

- In 1758 in the 10th edition of book "Systema Nature" he gave the classification of known 4236 animals
- each name have 2 parts:-
  - First part is genus and second part is species name.
  - First alphabet of genus is written in capital & rest in small.

- **Linnaeus classified animal kingdom into 6-classes on the basis of structures. It was an artificial classification**:

1. Mammalia
2. Aves
3. Amphibia
4. Insecta
5. Pisces
6. Vermes

In 1901, in the International Zoology Congress, approved International rules for Binomial system.

- In 1961, certain modifications were made in the Binomial system. In certain species, sub-species are also found. Now three words are used. First is of genus second of species and third is of subspecies. The method of nomenclature of Sub-species is termed as the "Trinomial Nomenclature" and it was given by "Huxley and strickland". e.g. The name of Indian, Burmese and the Srilankan crow according to this system is-
  - *Corvus splendens splendens* – **Indian and Pakistani crow.**
  - *Corvus splendens insolens* – **Burmese crow.**
  - *Corvus splendens protegatus* - **Srilankan crow.**

- **"G.L. Cuvier" :** Gave the term "phylum & Sub phylum. New-systematics" word was proposed by Julian-Huxley.
- **R.H. Whittaker :** He gave the Five kingdom scheme of animal-classifications - as follows

Characters	Five Kingdoms				
	Monera	**Protista**	**Fungi**	**Plantae**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellulosic (Polysaccharide + amino acid)	Present in some	Present with chitin	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multiceullar/ loose tissue	Tissue/ organ	Tissue/organ/ organ system
Mode of nutrition	Autotrophic (chemosyn-thetic and photosynthetic) and Hetero-trophic (sapro-phytic/para-sitic)	Autotrophic (Photosyn-thetic) and Hetero-trophic	Heterotrophic (Saprophytic/ Parasitic)	Autotrophic (Photosyn-thetic)	Heterotrophic (Holozoic/ Saprophytic etc.)

- **Storer And Usinger :** They gave the modern classification of the 5-kingdom system. In modern classification the animals have been classified into 10 major and 21 minor phylum.

Types of Species

- **Agamospecies :** The species which reproduce asexually are known as agamospecies.
- **Gamospecies :** The species in which inter breeding takes place are called gamospecies. It is also known as Biological species.
- **Sympathetic Species :** Two or more than two species occupying identical habitat or area are called sympathetic species.
- **Allopatric Species :** Two or more species which are inhabiting different geographical condition are called allopatric species.
- **Synchronic Species :** Two or more than two species which are found in same time period are called synchronic species.
- **Allochronic Species :** Two or more than two species that are found in different time period are called allochronic species.
- **Palaeo/Palaeontological species :** The species which are found in the form of fossils now a day are called palaeo species.
- **Neontological species :** The species which is present in living form, called neontological species.
- **Monotypic species :** Species that are not sub divided into subspecies are called monotypic species.
- **Polytypic species :** Species that contain two or more subspecies are called polytypic species.
- **Key stone species :** Species that which determines biotic structure of entire community by predation or any control mechanism.

Sequence of Classification

- Smallest unit of classification is "Species". It includes animals capable of interbreeding.
- Genus includes similar species.
- Family is made up of similar genera.
- Many families join together to form an order,
- many orders join together to form a class and
- many classes form a Phylum.
- All the phyla unite to form the largest unit Kingdom.

International Code of Botanical Nomenclature (ICBN)

- The International Code of Botanical Nomenclature is the set of rules according to which plants are given their botanical names (scientific names). The code specifies the standards and forms of names to be applied to each taxon of plants.
- According to the code May 1,1753, the date of publication of Linnaeus' *Species Plantarum*, is considered the starting point of present day nomenclature.

Topic: NITROGEN METABOLISM: NITROGEN CYCLE

- The nitrogen cycle refers to the movement of nitrogen through the food chain of living organisms . This complex cycle involves bacteria, plants and animals. All organisms can convert **ammonia (NH_3)** to organic nitrogen compounds, that is compounds containing C-N bonds.
- However, only a few microorganisms can synthesize ammonia from nitrogen gas (N_2).
- Although N_2 gas makes up about 80% of the earth's atmosphere, it is a chemically unreactive compound. The first stage in the nitrogen cycle is the reduction of N_2 gas to ammonia, a process called **nitrogen fixation**. Ammonia can also be obtained by reduction of nitrate ion (NO_3) that is present in the soil.
- **Nitrate reduction** can be carried out by most plants and microorganisms. The ammonia resulting from these two processes can then be assimilated by all organisms.
- Within the biosphere there is a balance between total inorganic and total organic forms of nitrogen.
- The conversion of organic to inorganic nitrogen comes about through catabolism, denitrification and decay.

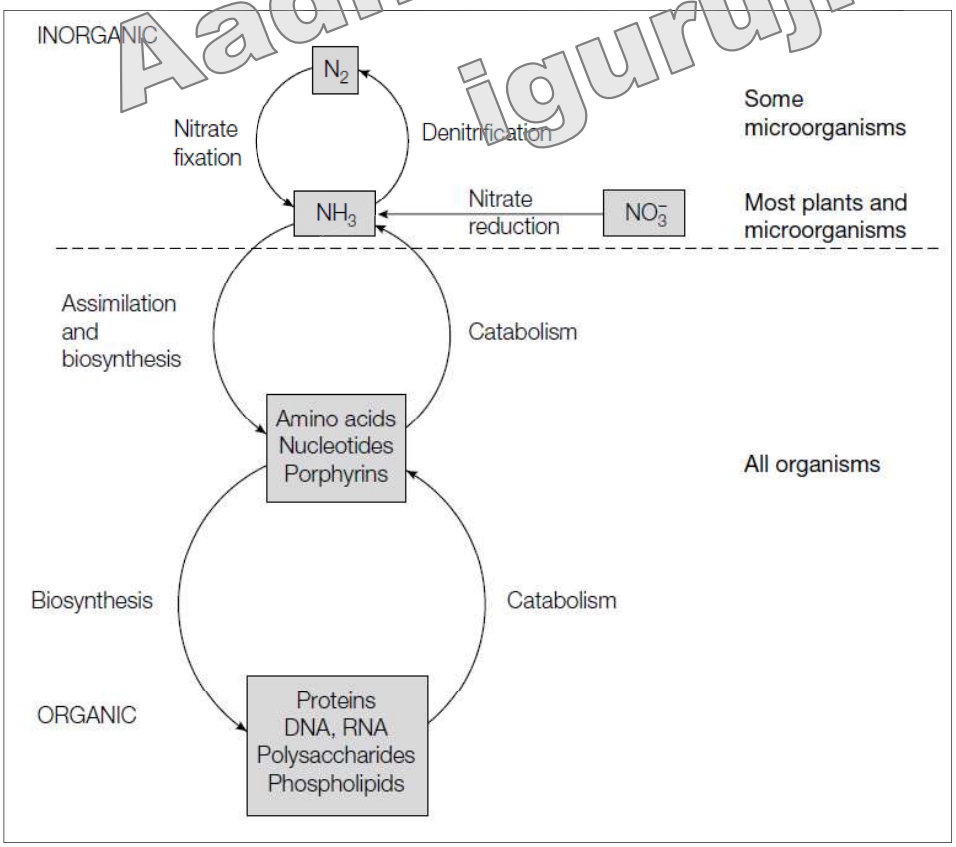


Fig. The interrelationships between inorganic and organic nitrogen metabolism.

Nitrogen fixation:

- The process of converting atmospheric N_2 gas into ammonia (nitrogen fixation) is carried out by only a few microorganisms, termed **diazatrophs**.
- These are some free-living soil bacteria such as *Klebsiella* and *Azotobacter,* cyanobac-teria (blue-green algae), and the **symbiotic bacteria** (mainly *Rhizobium).*
- The symbiotic *Rhizobium* bacteria invade the roots of leguminous green plants (plants belonging to the pea family, e.g. beans, clover, alfalfa) and form root nodules where nitrogen fixation takes place.
- The amount of N_2 fixed by these diazatrophic microorganisms has been estimated to be in the order of 10^{11} kg per year, about 60% of the earth's newly fixed nitrogen. Lightning and ultraviolet radiation fix another 15%, with the remainder coming from industrial processes.
- **The chemical unreactivity of the N=N bond is clearly seen when one considers the industrial process of nitrogen fixation.**
- **This process, devised by Fritz Haber in 1910 and still used today in fertilizer factories, involves the reduction of N_2 in the presence of H_2 gas over an iron catalyst at a temperature of 500°C and a pressure of 300 atmospheres.**

$$N_2 + 3\ H_2 \longleftrightarrow 2\ NH_3$$

Nitrogenase complex

- Biological nitrogen fixation is carried out by the **nitrogenase complex** which consists of two proteins: a **reductase**, which provides electrons with high reducing power, and a **nitrogenase**, which uses these electrons to reduce N_2 to NH_3. The reductase is a 64 kDa dimer of identical subunits that contains one iron-sulfur cluster and two ATP binding sites.
- The nitrogenase is a larger protein of 220 kDa that consists of two α and two β-subunits ($\alpha_2\beta_2$) and contains an iron-molybdenum complex. The transfer of electrons from the reductase to the nitrogenase protein is coupled to the hydrolysis of ATP by the reductase.

Although the reduction of N_2 to NH_3 is only a six-electron process:

$N_2 + 6\ e^- + 6\ H^+ \rightarrow 2\ NH_3$

the reductase is imperfect and H_2 is also formed. Thus two additional electrons are also required:

$N_2 + 8\ e^- + 8\ H^+ \rightarrow 2\ NH_3 + H_2$

The eight high-potential electrons come from reduced **ferredoxin** that is produced either in chloroplasts by the action of photosystem I or in oxidative electron transport. The overall reaction of biological nitrogen fixation:

$N_2 + 8\ e^- + 16\ ATP + 16\ H_2O \rightarrow 2\ NH_3 + H_2 + 16\ ADP + 16\ P_i + 8\ H^+$

highlights that it is energetically very costly, with at least 16 ATP molecules being hydrolyzed.

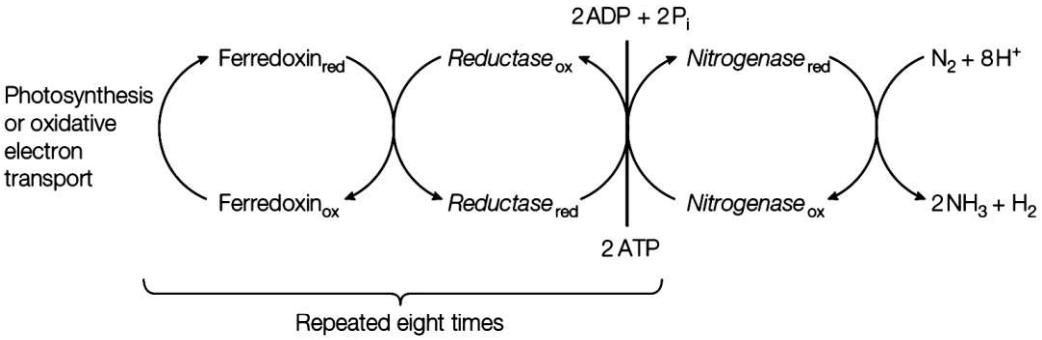


Fig. The flow of electrons in the nitrogenase-catalyzed reduction of N2

Leghemoglobin

- The nitrogenase complex is extremely sensitive to inactivation by O_2, so the enzyme must be protected from this reactive substance. In the root nodules of leguminous plants, protection is afforded by the symbiotic synthesis of leg-hemoglobin.
- The globih part of this monomeric oxygen-binding protein is synthesized by the plant, whereas the heme group is synthesized by the *Rhizobium.*
- The leghemoglobin has a very high affinity for O_2, so maintaining a low enough concentration to protect the nitrogenase.
- **Nitrogenase Components** → Nitrogenase has two components.
- Mo Fe Proteins → it is a tetramer with a molecular weight of approximately 220,000. It has two different types of subunits namely α and β. The structure of the tetramer is α2 β2. it is also called as Protein 1, Molybdo ferredoxin, Azoferno or dinitrogenase. It contains both Mo and Fe.
- **Fe Protein**:- It is a dimmer of two identical subunits. It is referred to as γ2. it contains Fe but no Mo. Fe-protein is also caused as protein 2, Azoferredoxin, Azofer or Dinitrogenase reductase. Molecular weight of the dimmer varies between 57, 000 and 72, 000.
- **Oxygen Sensitivity** → The enzyme nitrogenase is exteremely sensitive to oxygen. It is irreversibly inactivated in the presence of oxygen. It is able to reduce nitrogen to ammonia under microaerobic or anaerobic conditions. So, it can be concluded that oxygen is prevented from gaining access to the N_2 fixing enzyme sites.
- **Reason of inactivation of nitrogenase by oxygen**:-
- Both components of nitrogenase are sensitive to oxygen, though the Fe-protein, with a half decay time in air of 0.75 min is more rapidly inactivated than is the Mo-Fe protein with a half decay time in air of 10 min. Because of this extreme sensitivity shielded from oxygen.
- The mechanism of oxygen inactivation of nitrogenase is not clear. The toxicity of oxygen is usually explained in terms of the reduction of oxygen to superoxide (O_2^-).
- $O_2 + 2\ e^- \longrightarrow O_2^{-\cdot}$

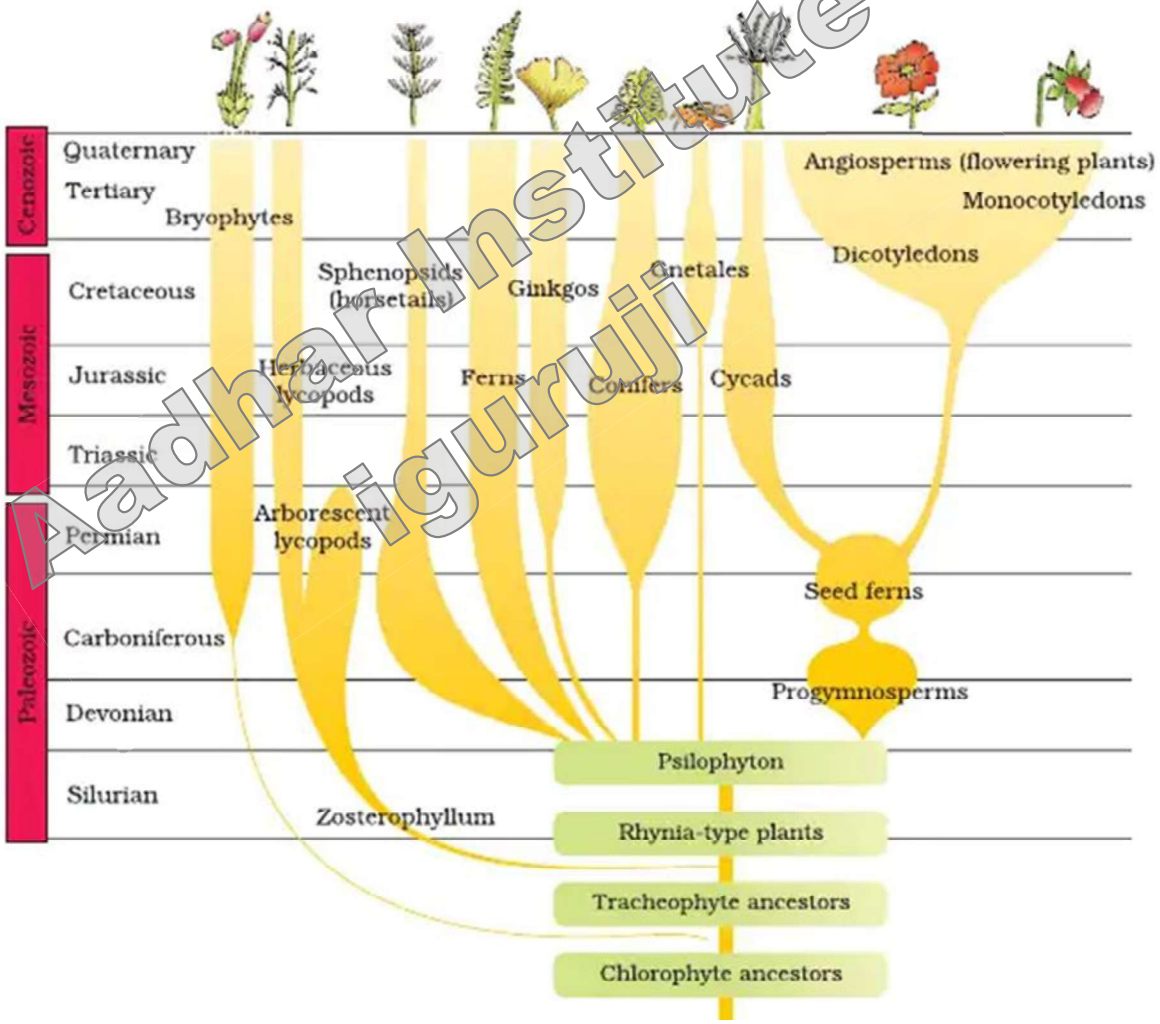
- In aqueous environment, superoxide forms perhydroxy radical.
- $O_2^- + H^+ \longrightarrow HO_2$
- and also react with itself to form hydrogen peroxide (H_2O_2)
- $O_2^- + O_2^- + 2H^+ \longrightarrow H_2O_2 + O_2$
- Superoxide react with hydrogen peroxide to produce hydroxyl radicals (OH).
- $H_2O_2 + O_2^- \longrightarrow O_2 + OH + OH^-$
- Hydroxyl radicals attack and degrade almost every molecule found in living organism, and ae responsible for many of thw observed toxic effects of oxygen. Many orgaism fix nitrogen only under atmosphere containing decreased concentrations of oxygen, and even those organism that can fix nitrogen aerobically are usually adversely affected by exposure to elevated concentration of oxygen.
- In some bacteria, not only does oxygen affect nitrogenase activity, but it also represses the synthesis of the enzyme. Thus, all N_2 fixing organism must protect nitrogenase from the deleterious effects of oxygen.

Nitrogen Assimilation :

- The next step in the nitrogen cycle is the assimilation of inorganic nitrogen, in the form of ammonia, into organic nitrogen-containing compounds. All organisms assimilate ammonia via two main reactions catalyzed by **glutamate dehydrogenase** and **glutamine synthetase** giving rise to the amino acids glutamate (Glu) and glutamine (Gin), respectively.

The amino nitrogen in Glu and the amide nitrogen in Gin are then used in further biosynthetic reactions to give rise to other compounds.

	Silurian		438	Diversity of lawless vertebrates; colonization of land by plants and arthropods; **origin of vascular plants**
	Ordovician		505	**First vertebrates (jawless fishes);** marine algae abundant
	Cambrian		544	Origin of most invertebrate phyla; diverse algae
Precambrian			700	**Origin of first animals**
			1500	Oldest eukaryotic fossils
			250	Oxygen beings accumulating in atomosphere
			3500	Oldest definite fossils known (prokaryotes)
			4600	Approximate origin of Earth



TOPIC: TYPES OF EVOLUTION

SEQUENTIAL AND DIVERGENT EVOLUTION

(i) Minor changes in the gene pool of a population from one generation to the next, with the result that no new populations are formed, but the descendent population is not genetically identical with its predecessor. This is known as sequential evolution.

(ii) The changes which result in the evolution of new populations, species, families, groups or classes represent as divergent evolution.

1. MICROEVOLUTION

The evolution, which results from the interaction of the elemental forces of evolution (i.e. mutation, variations, recombination, natural selection and the genetic drifts) to producer relatively small changes in the population or populations, is known as microevolution.

Microevolutionary forces operating for a shorter period produce sequential evolution, whereas when continued for generations together result in the evolution of new populations from the existing one. The origin of new populations can occur in two different ways-

(i) in a successional manner, and

(ii) in a divergent manner.

The successional microevolution is the evolution within a single population which results in the successional replacement of the pre-existing populations by the new once. This could be seen in successive strata of palaeontological series. It leads the micro-evolution to the formation of clines, when characters of a population seem to change gradually across its place of distribution. The formation of clines is an example of gradual changes in response to gradual changes in the climate.

The divergent microevolution results in the splitting of parental population into two or more new populations with the appearance of genetic divergence. Isolation is the additional factor operating to establish genetic divergence in the related populations.

2. MACROEVOLUTION (ADAPTIVE RADIATION)

The evolution, which results in the production of new adaptive types through a process of population fragmentation and genetic divergence, is known as macroevolution. It operates above the species level and results in the splitting of the population of species into several subgroups, each of which exhibits changes in a definite adaptive direction. These changes are known as adaptive trends and the phenomenon as the adaptive radiation or macroevolution. It means macroevolution is actually adaptive radiation.

►**Mechanism of macroevolution** - Macroevolution operates above species level and results in the establishment of new genera, families and orders. The changes in the organization occur on account of sudden mutations of large size, which are named “macro mutations” or “systematic mutation” by **Goldsehmidt. Macroevolution** occurs in a group of individuals which have entered a new adaptive zone free of competition.

3. MEGAEVOLUTION

Megaevolution has been described as the origin or evolution of new types of biological organization as a result of general adaptation from its predecessor, resulting in the formation of new classes, groups of phyta. Megaevolutionary changes are rare and have occurred only a few times in the evolutionary history of persist without extinction (with few exceptions).

MECHANISM OF MEGAEVOLUTION

During mega-evolution the organisms of the ancestral stock attempt to entera new zone, which is uninhabited by these forms and its devoid of competition. These exhibit varied modifications in different directions until one of these is found suitable to the new zone. It means a group of individuals of the parental stock develops certain generalized preadaptaions which unable them to enter the new zone. Therefore, these make a break - through into the new adaptive zone and start radiating into all the available habitats, thereby developing more specialized which are known as postadaptations.

►PATTERENS OF EVOLUTION

When morphological changes undergone by evolving higher taxa are plotted through time, distinctive patterns similar to those displayed in speciation are found. These are as follows-

1. Adaptive Divergence or Divergent evolution- When lineages split and evolve along separate adaptive pathways showing increased morphological differences in a given biospace, it is called adaptive divergence or divergent evolution. Divergent evolution is also seen when separate lineages follow different morphological solutions to the same problems.

2. Adaptive radiation or Radiation evolution- It shows splitting up of a number of lineages from some primitive group and these lineages modify and evolve to exploit a number of distinctive biospaces. This results in multiple divergence. Such evolutionary changes represent radiation evolution. Diversification of stegocephalian amphibians of various mammalian orders from their primitive ancestral forms represent adaptive radiation.

3. Parallel evolution- In parallel evolution two or more distinct lineages evolve along similar lines under the influence of similar environmental opportunities or requirements. As a result these exhibit similar morphological changes. best example of parallel evolution is found in arthropods. Arthropods are said to exhibit polyphyletic origin and it is presumed that 2 to 4 separate lineages of annelid - like worms have separately undergone arthropodization.

4. Iterative evolution- In iterative evolution similar sequences of morphological codification appear successively from the basic stock. For example, irregularly coiled ammonites (heterostrophic) have arisen three or more times from coiled ancestors.

5. Adaptive convergence or Convergence evolution- In this case separate lineages assumes similar morphology under the influence of similar environmental factors. For example, dolphins and whales (mammals) have fish-like appearance to lead a successful aquatic life.

►*Monophylectic And Polyphylectic Species*

Taxa whose members have descended from a common ancestor are called **monophylectic**. All members or species of monophylectic taxon descend either from the same parents or same population or same species i.e. the new species is the temporal extension of the parent species.

Taxa whose members are descended from diverse ancestral lineages are called **polyphylectic**.

►**ANAGENESIS** represent change in character of a lineage through time or linear succession of lineages through time i.e. succession of one species by other in due course of time. It is characterized by the replacement of one lineage by another.

Anagenesis creates organisms with novel characters and abilities, beyond those of their ancestors.

►**CLADOGENESIS** represents divergent evolution in which parental population of parental lineage splits or branches into several lineages. Lineage branches resulting from cladogenesis are called clades and are monophbylectic. This ensures rapid origin of new species.

►**STASIGENESIS** is a condition in which lineages neither split nor changes but persist unchanged. For example, turtles, Sphenodon, Coelacanths all represent stasigenesis.

George Gaylord Simpson noted two modes of evolution-

►**Bradytelic evolution**- (G. brady, means slow) - it includes evolution of new species rather slowly and gradually in relatively minor ways. This can also be called gradualism.

► **Tachytelic evolution** (G. tachy, means fast) - it includes origin of species by abrupt changes. As a result, the intermediate fossil forms are absent. This type of evolution is called punctuationism.

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CONTENT SECONDARY LEVEL

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TOPIC: Basics of Classification

▪ **A basic principle of taxonomic art is that its results should be useful.**

There are three basis subsidiary principle are:

1. The basis of the classification should be the most biologically significant relationships among organisms and should bring as many of those as is practicable.
2. Classification should be consistent with the relationship used as its basis.
3. Classification should be as stable as it can be without contravening the two preceding principles.

- Classification is an absolutely essential means of conceptualization, communication and storage of information about animals.
- Despite the fact that a bewildering variety of species with different structures and forms exist out there, organisms share some common features among themselves. These similarities are the basis of classification.
- Classification is the systematic arrangement of things around us for easy identification and study. The basis of classification can vary according to the purpose of the classification.
- A biological classification generally pins out the morphological and evolutionary similarities as its basis. **A consistent evolutionary classification is one whose implications drawn according to stated criteria of such classification., do not contradict the classifier's view as to the phylogeny of the group.**
- The principle kinds of criteria, used to draw up an evolutionary classification and to study their implications are:

  1. Criteria related to objectivity, reality, arbitrariness, and the like.

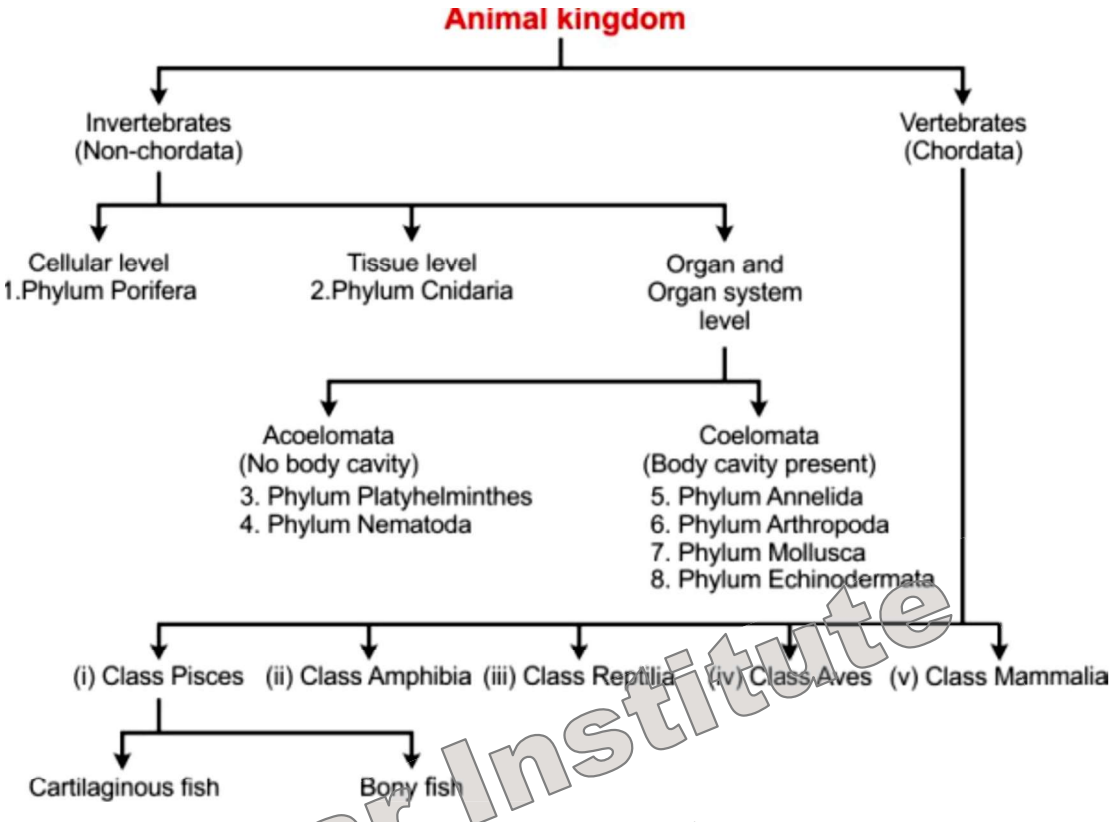
  2. Criteria related to monophyly, polyphyly, clades and grades .

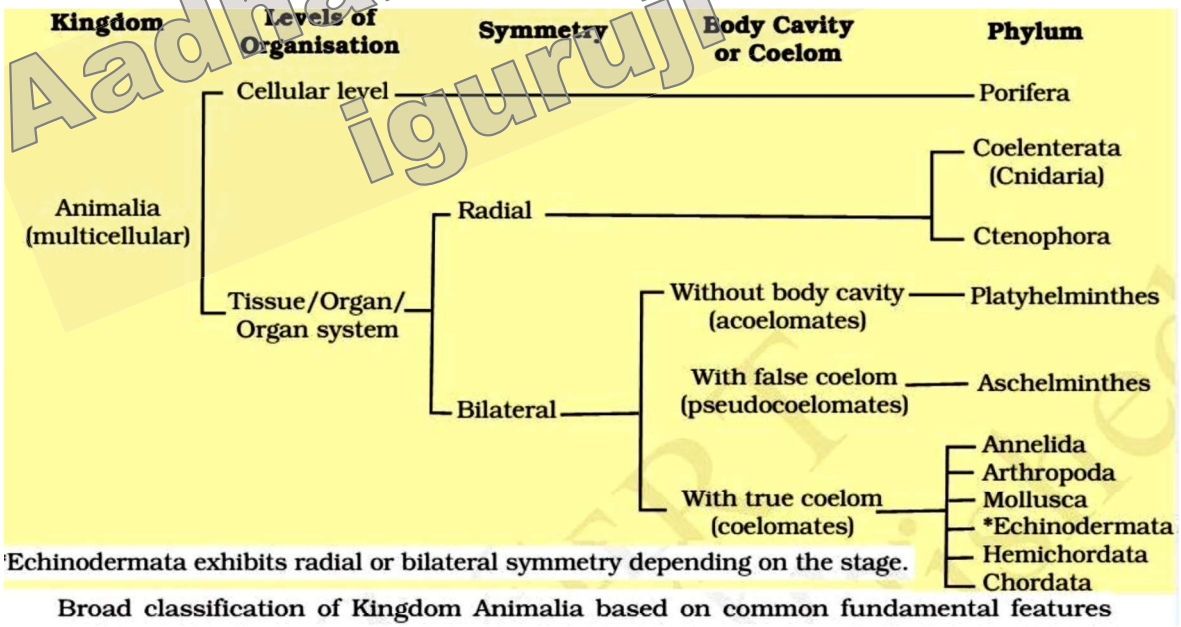
  3. Criteria related to the different kinds and degree of affinities involved in phylogeny.

  4. Criteria related to the relative antiquity of taxa.

▪ Classification of Animal Kingdom up to class in each phyla, although consider different characters in case of different phyla, but in general, the following criteria are considered for classification of animal kingdom:

1. body plan / Levels of Organisation,
2. Diploblastic and Triploblastic Organisation (germ cells)
3. Symmetry
4. Coelom development,
5. Segmentation of the body and
6. Presence or absence of Notochord
7. Larva stages
8. appendages





Broad classification of Kingdom Animalia based on common fundamental features

Levels of Organisation:

▪ Though all members of *Animalia* are multicellular, all of them do not exhibit the same pattern of **organisation of cells.**

▪ For example, in sponges, the cells are arranged as loose cell aggregates, *i.e.*, they exhibit cellular level of organisation. Some division of labour (activities) occur among the cells.

▪ In *Coelenterates*, the arrangement of cells is more complex. Here the cells performing the same function are arranged into tissues, hence is called **tissue level of organisation**.

▪ A still higher level of organisation, i.e., organ level [**organ level of organisation**] is exhibited by members of *Platyhelminthes* and other higher phyla where tissues are grouped together to form organs, each specialised for a particular function.

▪ In animals like *Annelids, Arthropods, Molluscs, Echinoderms* and *Chordates*, organs have associated to form functional systems, each system concerned with a specific physiological function. This pattern is called **organ system level of organisation.**

▪ Organ systems in different groups of animals exhibit various patterns of complexities.

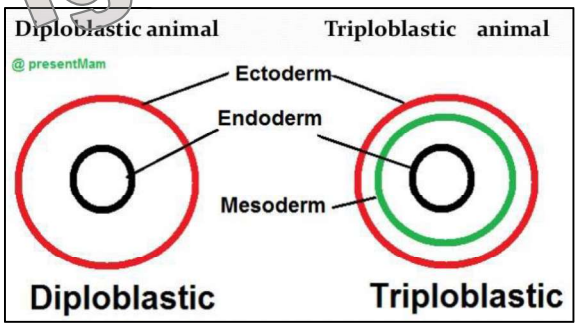
Example:

▪ The digestive system in *Platyhelminthes* (incomplete digestive system) has only a single opening to the outside of the body that serves as both mouth and anus, and is hence called incomplete. A complete digestive system has two openings, mouth and anus.

▪ Similarly, the circulatory system may be of two types: open type in which the blood is pumped out of the heart and the cells and tissues are directly bathed in it and closed type in which the blood is circulated through a series of vessels of varying diameters (arteries, veins and capillaries).

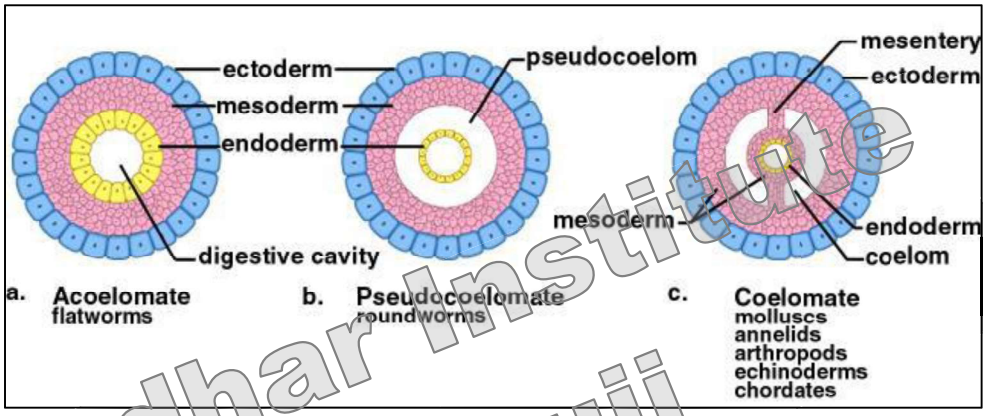
Diploblastic and Triploblastic Organisation:

- Animals in which the cells are arranged in two embryonic layers, an external ectoderm and an internal endoderm, are called diploblastic animals, e.g., Coelenterates. An undifferentiated layer, mesoglea, is present in between the ectoderm and the endoderm.
- Those animals in which the developing embryo has a third germinal layer, mesoderm, in between the ectoderm and endoderm, are called triploblastic animals (platyhelminthes to chordates).



TOPIC: COELOM:

- **The coelom** is the main body cavity in most animals and is positioned inside the body to surround and contain the digestive tract and other organs. In some animals, it is lined with mesothelium. In other animals, such as molluscs, it remains undifferentiated. Coelom is the mesodermally lined cavity between the gut and the outer body wall.
- During the development of the embryo, coelom formation begins in the gastrulation stage. The developing digestive tube of an embryo forms as a blind pouch called the archenteron. In the past, and for practical purposes, coelom characteristics have been used to classify bilaterian animal phyla into informal groups.
- It is one of the significant criteria, being considered as the basis of classification of animal kingdom.



ACOELOMATES:

- Acoelomates lack a fluid-filled body cavity between the body wall and digestive tract. This can cause some serious disadvantages. Fluid compression is negligible, while the tissue surrounding the organs of these animals will compress.
- Therefore, acoelomate organs are not protected from crushing forces applied to the animal's outer surface.
- Usually, the coelom can be used for diffusion of gases and metabolites etc. These creatures do not have this need, as the surface area to volume ratio is large enough to allow absorption of nutrients and gas exchange by diffusion alone, due to dorso-ventral flattening.

Example:

- Cnidarians (jellyfish and allies), and the ctenophores (comb jellies),
- Platyhelminthes
- Gastrotricha, traditionally viewed as blastocoelomates
- Entoprocta, traditionally viewed as blastocoelomates
- Gnathostomulida, traditionally viewed as blastocoelomates
- Cycliophora

PSEUDOCOELOMATE:

- ▪ **Pseudocoelomate animals have a pseudocoelom** (literally "false cavity"), which is a fluid filled body cavity. Pseudocoelomate animals are also referred to as Blastocoelomate. A pseudocoelomate or blastocoelomate is any invertebrate animal with a three-layered body and a pseudocoel.
- The coelom was apparently lost or reduced as a result of mutations in certain types of genes that affected early development. Tissue derived from mesoderm partly lines the fluid filled body cavity of these animals.
- Thus, although organs are held in place loosely, they are not as well organized as in a coelomate Thus, pseudo coelomates evolved from coelomates.
- "Pseudo-coelomate" is no longer considered a valid taxonomic group, since it is not monophyletic.
- However, it is still used as a descriptive term. All pseudo-coelomates are protostomes; however, not all protostomes are pseudo-coelomates.

Important characteristics:

- Most are microscopic parasites of almost every form of life (although some are free living), body usually covered by a secreted cuticle.
- Lack any kind of segmentation, a vascular blood system and a true skeleton, although hydrostatic pressure gives the body a supportive framework that acts as a skeleton.
- Diffusion and osmosis circulate nutrients and waste products throughout the body.
- They are often syncytial. They possibly represent pedomorphism. Larval stages are lost in some forms.

Examples:

Rotifera, Kinorhyncha, Nematoda, Nematomorpha ,Acanthocephala, Loricifera, Ecdysozoans pseudocoelomates, Nematoda (roundworms), Nematomorpha (nematomorphs or horsehair worms), Loricifera, Priapulida, Kinorhyncha, Lophotrochozoans, pseudocoelomates, Gastrotricha, Entoprocta, Rotifera (rotifers), Acanthocephala (spiny headed worms).

COELOMATE:

- **Coelomate animals or Coelomata** (also known as **Eucoelomates** – "true coelom") have a body cavity called a coelom with a complete lining called peritoneum derived from mesoderm (one of the three primary tissue layers). The complete mesoderm lining allows organs to be attached to each other so that they can be suspended in a particular order while still being able to move freely within the cavity.

Examples: According to Brusca and Brusca, the following bilaterian phyla possess a coelom: Nemertea, traditionally viewed as acoelomates, Priapulida, Annelida, Onychophora, Tardigrada, Arthropoda, Mollusca, Phoronida, Ectoprocta, Brachiopoda, Echinodermata, Chaetognatha, Hemichordata and Chordata.

Two types of coelomic development schizocoelous and enterocoelous

Difference between schizocoelous and enterocoelous types can only be seen during embryonic development, once the coelom is fully developed they cannot be differentiated.

Schizocoelous coelom : Is found in Annelids, Arthropods and molluscs.

- A single micromere or mesentoblast cell pinches off from archenteron and it multiplies and proliferates to from mesodermal patches between the developing archenteron (endoderm) and the body wall (ectoderm)

TOPIC : SOCIAL BEHAVIOR

▶An animal society is a relatively **permanent union of individuals held together by mutual attraction of its members.**

▶Any interaction between one individual of a species with another member of the same species is known as social behavior, this includes all those behaviors that influence, or are influenced by other members of the same species.

▶A true society will involve more than a mated air i.e. adults, subadults, juveniles, infants of different age-sex classes. It will mean a stable group whose members inter-communicate extensively and bear some relatively permanent social relationship to one another.

Characteristics of social groups and behavior

(1) The first and most obvious characteristic of social behavior involves the number of animals of the same species that actively come together or remain together in a group. The minimum level of sociality or the smallest social group is found between a male and female who interact only during breeding season or between mother and infant.

(2) Social behavior depends in part on the "length of time or part o the life cycle that the group remain together."

(3) As opposed to the length of time that the members are simply in a group, that is, in physical proximity to each other, this element concerns the "energy actually spent in social behavior".

(4) **"Reciprocal communication"** is generally considered necessary as a mechanism for attracting and keeping them members of a group together.

(5) Much social behavior is marked by a division of labour and "social structure or what is frequently or what is frequently referred to as roles."

(6) A feature of social group in many species is an "overlap of generations;" that is, families or parts of families may stay together. Parents defend or protect their young ones.

(7) The last point represents the highest level of social behavior "Altruistic or aid giving behavior where there is a cost to the altruistic individual" IN most extreme forms it includes even the sacrifice of one's life and reproduction. Origin and existence of sterile or non-reproductive castes among ants, bees, wasps and termites poses a difficult problem for natural selection theory, as, such individuals are not maximizing their own reproductive potential, instead, they work for the benefit of the colony. They have probably evolved through indirect or kin selection.

Four properties of organized societies :

1. Communication. All organized societies have some form of complex communication system. The members of a social group make gestures, postures, change colour, raise hair, thev scent mark, communicate through vocalization, they may indicate messages by touching each other, or have some specialized forms like ecolocation in bats, tail and waggle dance in bees.

2. Cohesion. The individuals constituting a society tend to remain in close proximity to one another e.g. all the bees of a group live in one hive, the individuals in a herd of deer, pride of lions and peck of wolves remain in close vicinity in a given home range, the individuals in a troop of baboons while moving tend to remain in close proximity.

3. Division of labour. In organized societies, animals of different status sexes or age groups have different functions in maintaining the society. Baboon and macaque young adult males often serve as front or rear guard for group as the group moves, they are the ones to face predators. The old adult, dominant males remain in a more central place and they decide the foraging and resting areas, the function of females is to bear and bring up infants and care for young.

4. Permanence and impermeability. The individuals making up a society tend to be same. There is little migration from the group, in most mammals the core of the group is formed by females who are related to each other the males come and go, otherwise, the membership among females permanent. Most organized societies resist immigration by outsides.

Social Interactions

- **Communication, courtship mating parental care, aggressive interactions, territoriality, physical proximity (closeness), and grooming are important interactions among social animals.**

Degrees of sociality:

- **eusocial:**
  - individuals of the same species cooperate in caring for young
  - a division of labor exists in which more or less sterile individuals work on behalf of relatively few reproductive nest mates
  - at least 2 generations overlap enough for offspring to assist parents in performing colony labor during some part of their lives
  - all ants, most advanced wasps & bees, and all termites exhibit these traits
- **pre-social**
  - species characterized by 2 or fewer of the above traits
  - represented by a series of social stages:
    - **parasocial sequence**
      - adults belonging to the same generation assist one another to varying degrees (see table below)
      - may be the evolutionary pathway taken by bees

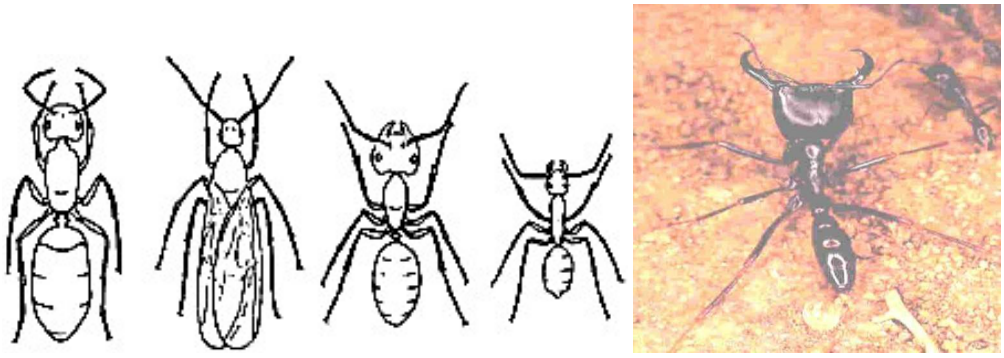
Degrees of sociality	Cooperative brood care	Reproductive castes	Overlap between generations
Solitary	-	-	-
Communal - females cooperate in constructing nest but rear broods separately	-	-	-
Quasisocial - cooperative care but each female still lays eggs	+	-	-
Semisocial - addition of 'worker' caste; some colony members never reproduce	+	+	-

- **subsocial sequence**
  - increasingly close association between mother and offspring (see table below)
  - may be the evolutionary pathway taken by ants, termites, social wasps, & some social bees

Degrees of sociality	Cooperative brood care	Reproductive castes	Overlap between generations
Solitary	-	-	-
Primitively subsocial - female provides care for a time but departs before young eclose as adults	-	-	-
Intermediate subsocial I - female present when young mature	-	-	+
Intermediate subsocial II - some of the young provide for the next brood	+	-	+
Eusocial - mature offspring remain permanently rather than leaving to rear own young	+	+	+

Caste differentiation in some eusocial insects:

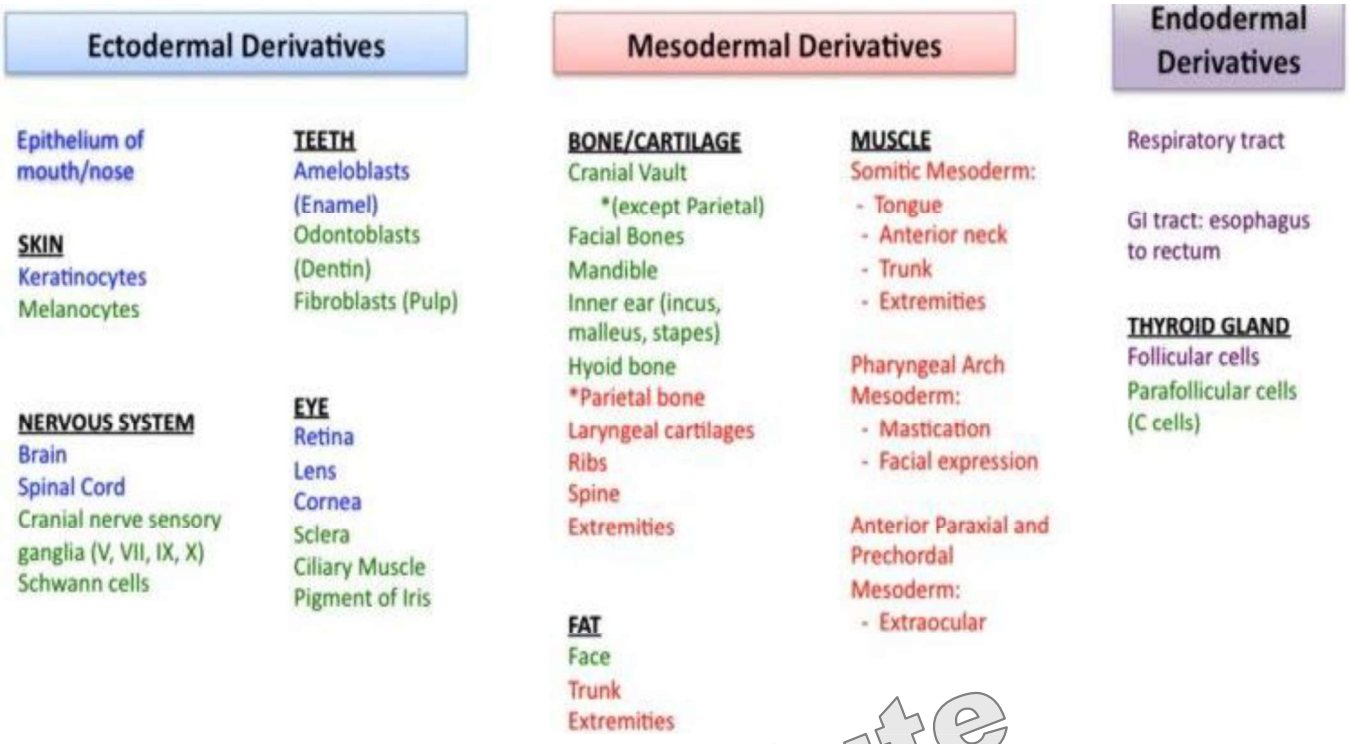
- **Ants**
  - **3 basic castes - queen, major worker (or soldier), & minor worker**



From left to right: Queen, Winged male, Major worker, & Minor worker.

- **Queen - fully reproductive** female whose main function is to lay eggs and, in some species, to start new colonies after mating
- **Major workers:**
  - unfertilized females
  - principal functions are colony defense and, in some species, food storage
  - specialized forms in some species:
    - many genera - mandibles designed for cutting integument & clipping off appendages of invading arthropods
    - army ants - possess pointed or hooked mandibles designed for piercing an opponent's integument
    - many species - possess shield- or plug-shaped heads used to block nest entrances
- **Minor workers:**
  - unfertilized females
  - functions include construction, brood care, care of the queen, and foraging
  - in most ants, the division of labor is based at least in part on age:
    - about first 50 days - in the nest caring for the brood, the queen, & other workers and cleaning the nest
    - after about 50 days - shift to outside activities, particularly foraging and nest construction
- **Males - not differentiated into castes & serve only as reproductives**

- Termites
  - different order (Isoptera) but caste system is similar to that of the social Hymenoptera
  - castes comprised of both males and females (not just females as in social Hymenopterans)
  - castes include:
    - **Primary reproductives**
      - consist of a monogamously mated female (queen, below left) and male (king, below right)



- **Formation of endoderm:** Endoderm of hypoblast develops as a single layer of cells in side of blastocoel. After the formation of endoderm, upper layer is called epiblast. **There are different theories to explain the formation of endoderm.**
- **Infiltration theory** : This was proposed by Peter in 1923. According to this theory some cells in blastoderm which are loaded with yolk will fall into blastocoel. It starts from posterior end of blastoderm. From there the cells migrate forward one behind another and endoderm is formed.
- **Delamination theory** : It was proposed by Spratt in 1946. Blastodenr.[1] is two or three layered thick. The lower layer will separate-fcoijl the upper layer by splitting and the lower layer is called endoderm, upperr layers are called ectoderm. In between ectoderm and endoderm blastocoel is .present.
- **Theory of involution** : In 1909 Peterson Proposed this theory. According to this theory a slit like opening at the posterior side of blastoderm forms. Through this opening the blastoderm cells will role into the primary blastocoel. It forms an endoderm.
- **Theory of invaginaton** : This was proposed by Jockobson in 1938. According to this theory the posterior end of blastoderm will invaginate in blastocoel as a small pocket. This becomes endoderm. In this way endoderm is formed.

Cell differentiation

a) is the process by which embryonic cells become different from one another (distinct identifies and functions).
b) involves the emergence of cell types such as muscle, nerve, skin and fat cells.
c) is the achievement of a stable terminal state (not just transitory differences).
d) involves a change in gene expression to produce "luxury" proteins.
e) is characterized by the profile of proteins present in that cell.
Microarray analysis can be utilized to study differences in gene expression.
The earliest stage of cell differentiation is cell determination where the cells becomes committed to a subset of cell fates.

►**How cells differentiate:**

The specialized properties of different cell types are conferred by the proteins they contain. The process of differentiation must therefore involve the synthesis of different sets of proteins in different cells. Exceptionally, this may be achieved by DNA rearrangement, as in the differentiation of antibody-producing blood cells. However, most cells contain the same DNA, and different sets of proteins are made by the selective expression or activation of particular gene products. The synthesis of a functional proteins is dependent on a series of steps including transcription, RNA processing, protein synthesis and posts-translational protein modification. Any or all of these stages can be regulated, so differentiation usually begins with the activation of a particular regulator molecule, such as a transcription factor

►**Lateral inhibition and the community effect**

Lateral inhibition is the inhibition of a particular developmental process in one cell by signals from an adjacent cell. Lateral inhibition can be used as a special form of induction, which involves an initially equivalent field of cells, yet results in the differentiation of individual cells in a regularly spaced pattern

► **Competence**

Competence is a property of the cell responding to induction. A cell is described as competent if it can respond to the inductive signal by undergoing all the appropriate molecular changes that allow it to follow the 'induced' develop-mental pathway. In the absence of induction, the cell eventually becomes deter-mined to an alternative pathway, and this coincides with its loss of competence to respond to induction. In the case of endocrine or paracrine signaling, competence depends on the synthesis of all the components of the signal transduction pathway that link the inductive signal to its target, such as a transcription factor, in the responding cell. If any of these components is lost, e.g. the cell surface receptor, the signal transduction apparatus, or the downstream target transcription factor itself, the cell loses competence. In the case of juxtracrine signaling, a cell may also lose competence simply by breaking contact with the inducing cell. This may reflect the movement of cells away from each other, or the disassembly of gap junctions.

► **Instructive and permissive Induction**

These two categories of induction reflect the choices available to the responding cell. Instructive induction occurs where the responding cell has a choice of fates and will follow one pathway in response to induction but an alternative pathway in the absence of induction.

Permissive induction occurs where the responding cell is already committed to a certain develop-mental fate, and simply requires the inducing signal to continue down that developmental pathway. An example is muscle development, where myoblasts continue to proliferate until growth factors are withdrawn, when they differentiate into myotubes and eventually muscle fibers

► **Instructive and permissive induction can be distinguished by grafting experiments**. For example, in mammals, the cardiogenic mesenchyme (future heart) is required to induce hepatocyte development in the presumptive liver-forming region of the foregut. The signals could be instructing the foregut to form hepatocytes instead of other cell types or could be permitting the differentiation of hepatocyte cells that have already been specified by other mechanisms. If the cardiogenic mesenchyme is grafted under the hindgut, no hepatocytes are induced. The inductive signals from the cardiogenic mesenchyme are therefore permissive rather than instructive.

► **Cytoplasmic determinants**

A cell can divide to produce two daughters committed to different fates in the absence of any external influences. Stem cells provide an excellent example of this process. Each division of a stem cell produces one daughter cell committed to differentiate, and a replacement stern cell. This stereotyped division program can occur in isolation, indicating that the mechanism of differentiation is entirely intrinsic. One way in which this could be achieved is through the asymmetric distribution of cytoplasmic determinants (molecules in the cytoplasm that can help to determine cell fate). If a mother cell contains a cytoplasmic determinant that is localized to one pole as the cell undergoes division, that determinant will be inherited by only one of the daughters.

MOSAIC AND REGULATIVE DEVELOPMENT

►Definitions of mosaic and regulative development

Cytoplasmic determinants and inductive signals can both be used to control cell fates. If development was controlled entirely by cytoplasmic determinants, the fate of every cell would depend on its lineage, while its position in the embryo would be irrelevant. This is the definition of mosaic development.

Conversely, if development was controlled entirely by inductive interactions, the fate of every cell would depend on its position in the embryo and its lineage would be irrelevant. This is the definition of regulative development. The development of most organisms involves a combination of these mechanisms. The two mechanisms are discussed in more detail below, and their key features are compared.

► **Regulative Development**

In regulative development, the fate of every cell is governed entirely by its interactions with other cells. Cell fate depends on position in the embryo and is independent of lineage. The potency of each cell is therefore much greater than its fate. During regulative development, each cell is said to undergo conditional specification, i.e. conditional on the presence of other cells. Therefore, if removed from the embryo, a given cell will not fulfil its normal fate because it lacks the necessary interactions. Furthermore, the remainder of the embryo can regulate to replace missing parts, because the appropriate inductive interactions have yet to take place, and other cells can be respecified to fill in the missing pattern. The fate map of a regulative embryo is not the same as a specification map, since cells in isolation will not develop in the same way as those in the embryo.

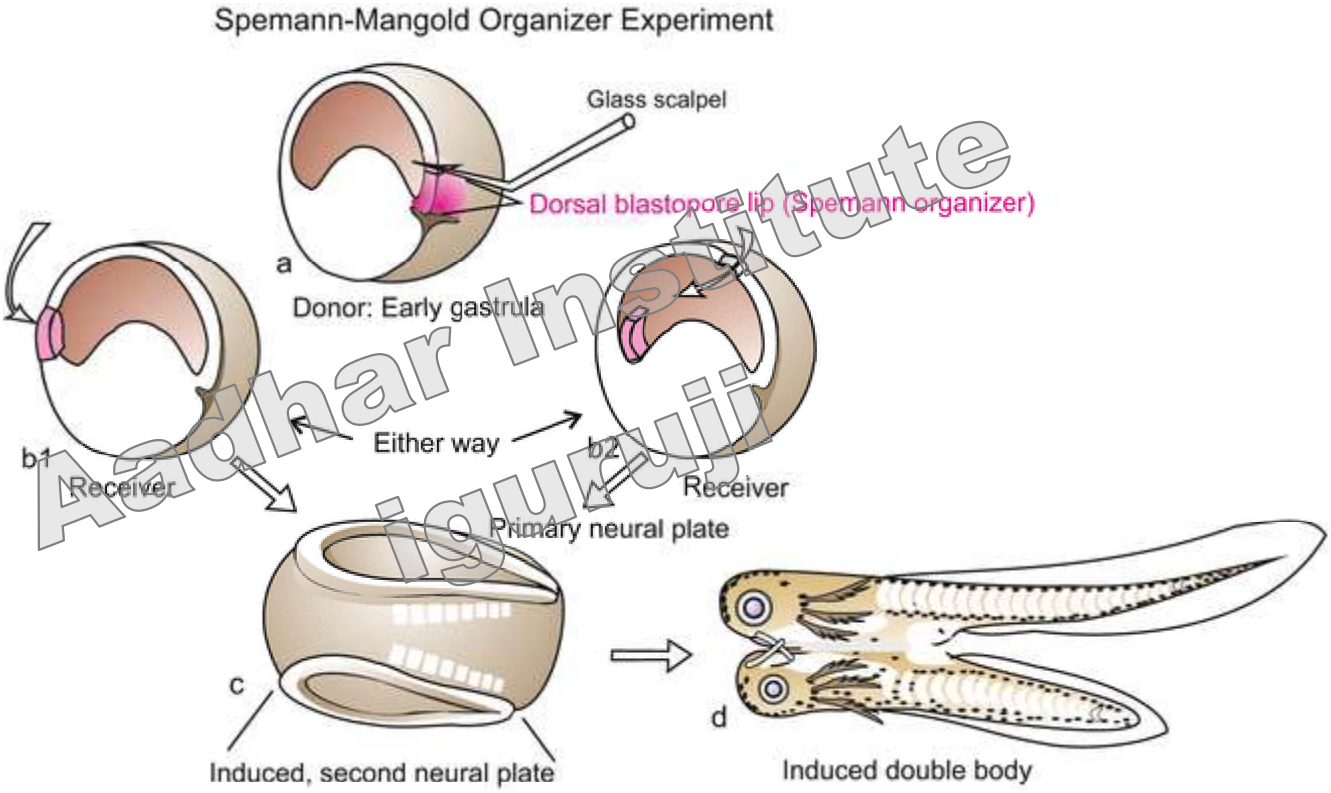
► **Maternal and zygotic genes**

Cytoplasmic determinants often feature in early animal development, where maternal gene products are localized in the egg to help pattern the early embryo. In such cases, early development becomes dependent on the maternal genome, while the paternal genome plays no part. This leads to an interesting class of mutants called maternal effect mutants, whose phenotypes are manifest in the embryos of mutant females, but not in the mutant females themselves. Furthermore, if the mutation is recessive and the female is homozygous for the mutation, embryonic development cannot be rescued by mating to a wild type male

TOPIC:Embryonic Induction

In amphibian embryos, the dorsal ectodermal cells in a mid-longitudinal region differentiate to form a neural plate, only when the chorda-mesoderm is below it. **Chorda-mesoderm is the layer formed by invagination cells from the region of the dorsal blastoporal lip, which form the roof of archenteron.**

- **Mangold (1927) selected a small part of dorsal blastoporal lip from an early gastrula of Triturus cristatus and grafted it at a place near the lateral lip of the blastopore of the host gastrula of T. taeniatus.**
- The graft cells grew in number and spread inside the host gastrula to form an additional chorda-mesoderm at this place. This chorda-mesoderm, subsequently induced the ectoderm of the host gastrula to form an additional neural tube.



The graft cells themselves formed an additional notochord. As the host gastrula developed further, it grew into a double embryo joined together.

- One of the embryos was the regular one, while the second was the induced one. The latter did not develop a complete head.
- This experiment clearly showed that the dorsal blastoporal lip of the blastula had the ability to induce the formation of the neural plate in the ectoderm of the host. **This phenomenon is called neural induction**..
- This influence of one structure in the formation of another structure is called embryonic induction.
- In fact, the entire development of an organism is due to a series of inductions.

- The structure, which induces the formation of another structure, is called the inductor or organizer. The chemical substance that is emitted by an inductor is called an evacuator.
- The tissue on which an evacuator or inductor acts is called the responsive tissue.

Historical Background of Embryonic Induction:

For the discovery of neural induction, the German embryologist, Hans Spemann and his student, Hilde Mangold (1924) worked a lot and for his work Spemann received Nobel Prize in 1935.

These two scientists performed certain heteroblastic transplantations between two species of newt, i.e., Triturus cristatus and Triturus taeniatus and reported that the dorsal lip of their early gastrula has the capacity of induction and organization of presumptive neural ectoderm to form a neural tube and also the capacity of evocation and organization of ectoderm, mesoderm and endoderm to form a complete secondary embryo.

- They called the dorsal lip of the blastopore the primary organizer since it was first in the sequence of inductions and as it had the capacity to organize the development of a second embryo.

Later on, the primary organizer was reported to exist in many animals, e.g. in frogs (Daloq and Pasteels, 1937); in cyclostomes (Yamada, 1938); in bony fishes (Oppenheimer, 1936); in birds (Waddington, 1933) and in rabbit (Waddington, 1934).

In 1960 and 1963 Curtis investigated and reported that the organizer of gastrula of Xenopus laevis can be distinguished in the cortex of gray crescent of a fertilized egg.

Types of embryonic induction:

Lovtrup (1974) classified different types of embryonic induction into two basic categories- endogenous and exogenous inductions.

1. Endogenous induction:

- Certain embryonic cells gradually assume new diversification pattern through the inductors that are produced by them endogenously.
- **Due to these inductors, these cells undergo either self-transformation or self-differentiation.** Examples of such induction were reported in Mesenchymal cells of ventral pole of Echinoid and in small sized, yolk-laden cells of dorsal lip of amphibian blastopore.

2. Exogenous induction:

- When some external agent or a cell or a tissue is introduced into an embryo, they exert their influence by a process of diversification pattern upon neighbouring cells through contact induction. This phenomenon is called exogenous induction.
- It may be **homotypic or heterotypic** depending on the fact that whether the inductor provokes the formation of same or different kind of tissues respectively.
- **In homotypic induction**, a differentiated cell produces an inductor. The inductor not only serves to maintain the state of the cell proper, but also induces adjacent cells to differentiate according to it, after crossing the cell boundaries. **Best example of the heterotypic exogenous**